Membrane Lipid

Content Type	Notes
Status	Done
Chapter	Cell - The Unit of Life, Membrane Structure and Function, Physical Structure of a cell
Course	Graduation
Reference	Dr. Najeeb, Kerp's Cell and Molecular Biology, Shomu's Biology
Subject	Biochemistry, Zoology
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Difficulty Level	
Mistake type	
Previous Year Questions	

Summarize and atleast remember points:

Visualize

The Lipid composition of membrane

Fluidity

Modification of lipids

The Nature and Importance of the Phospho-Lipid Bilayer

Self-assumble forming Liposome

The Asymmetry of Membrane Lipids

- Abundent phospholipid in inner membrane (Inner leaflet)
- Abundent phospholipids in outer membrane (outer leaflet)

Cholesterol
Factor affect Fluidity of Membrane
    Temperature:
    Cholesterol :
    Unsaturation of fatty acid:
Types of Membrane lipids
    Phosphoglycerides
    Glycolipids
    Sphingolipids
    Sphingolipids
Lipid Raft
    Analogy:

Summarize and atleast remember points:

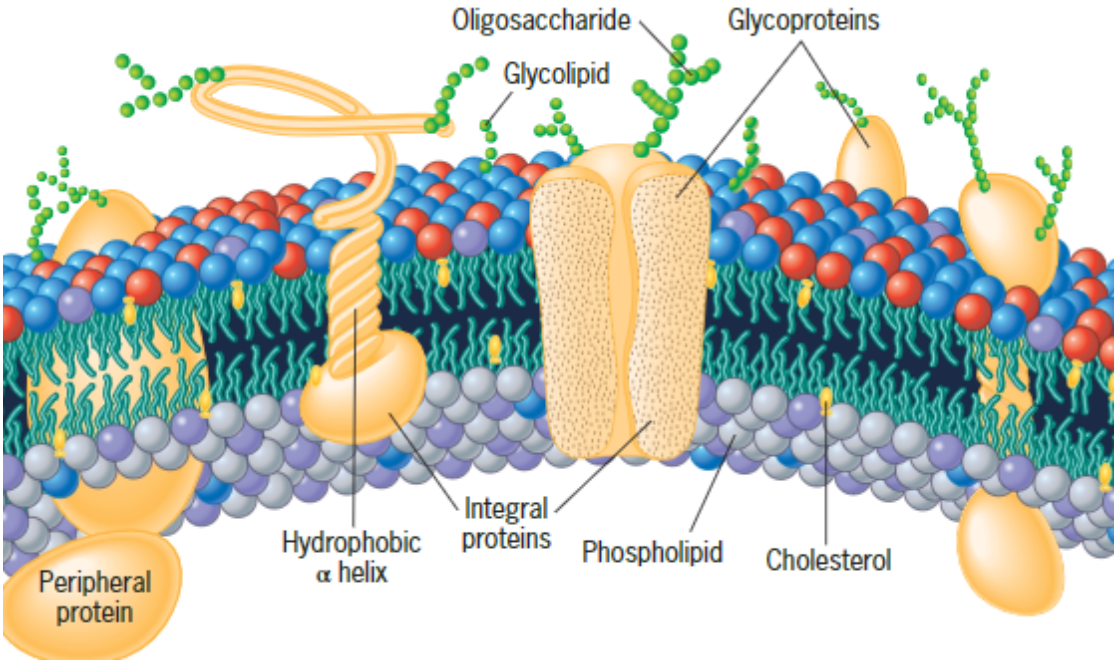
- The lipid composition of the membrane refers to the types and amounts of lipids that make up the membrane. The lipid composition of the membrane affects the membrane's fluidity and its ability to perform its functions.
- Fluidity: The fluidity of the membrane is important because it affects the ability of proteins to move within the membrane and carry out their functions. Lipids that are more fluid allow for greater movement of proteins, while lipids that are more rigid restrict protein movement.
- Modification of lipids: Lipids can be modified with various chemical groups, such as phosphate or carbohydrate, which affects their properties and functions.
- The nature and importance of the phospho-lipid bilayer: The phospholipid bilayer is the basic structure of the membrane, composed of two layers of phospholipid molecules. The polar, hydrophilic head of each phospholipid faces the outside and the inside of the cell, while the nonpolar, hydrophobic tails are in the middle of the bilayer. The phospholipid bilayer is important because it provides a barrier that separates the inside and outside of the cell and regulates the movement of molecules in and out of the cell.
- Self-assemble forming liposome: Liposomes are spherical vesicles composed of a phospholipid bilayer that spontaneously forms when phospholipids are suspended in an aqueous solution. Liposomes are useful for drug delivery and are also used in research to study the properties of the lipid bilayer.
- The asymmetry of membrane lipids: The distribution of lipids in the two layers of the membrane is not symmetrical. There are different types and amounts of lipids

in the inner and outer leaflets of the membrane.

- Abundant phospholipids in inner membrane (inner leaflet): The inner leaflet of the membrane is rich in phospholipids such as phosphatidylserine, phosphatidylethanolamine, and phosphatidylinositol. These lipids are important for membrane structure and function, as well as intracellular signaling.
- Abundant phospholipids in outer membrane (outer leaflet): The outer leaflet of the membrane is rich in phospholipids such as phosphatidylcholine and sphingomyelin. These lipids are important for membrane structure and function, as well as cell signaling and communication.
- Factors affecting fluidity of the membrane:
  - Temperature: As temperature increases, the membrane becomes more fluid. At very high temperatures, the membrane may become too fluid and lose its integrity.
  - Unsaturation of fatty acid: Membrane lipids with unsaturated fatty acids are more fluid than those with saturated fatty acids.
  - Cholesterol: Cholesterol can either increase or decrease the fluidity of the membrane, depending on the temperature and the lipid composition of the membrane.
- Types of membrane lipids:
  - Phosphoglycerides: These lipids are composed of a glycerol backbone, two fatty acids, and a phosphate group with a polar head group.
  - Glycolipids: These lipids are composed of a sphingosine backbone, a fatty acid, and a carbohydrate group with a polar head group.
  - Sphingolipids: These lipids are composed of a sphingosine backbone, a fatty acid, and a polar head group, which can be a phosphate group or a carbohydrate group.
  - Lipid rafts: These are specialized regions of the membrane that are enriched in cholesterol and sphingolipids, and are important for membrane organization and signaling.

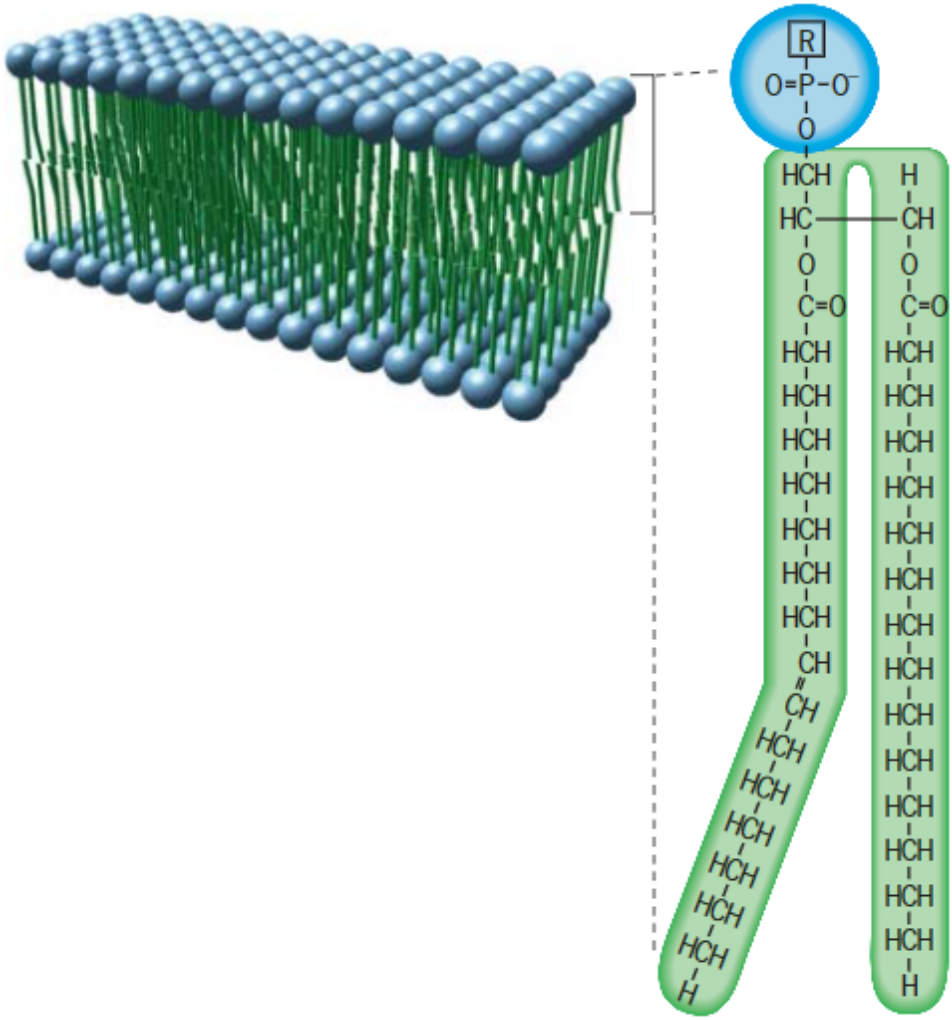
Visualize

🤨Plasma mebranes as lipid plus proteins:



Observe : 🔎External membrane have glucose + lipid = glycolipid , glucose + protein = glycoprotein. 🔎The two leaflets of the bilayer contain different types of lipids as indicated by the differently colored head groups.

🙈Bimolecular layer of phospholipids



Observe : 🔎 Their water-soluble head groups facing the outer surfaces and their hydrophobic fatty acid tails facing the interior.🔎Phospholipid head groups are purple, water molecules are blue, fatty acid chains are green.

The Lipid composition of membrane

- **Cell membrane is mainly composed of lipids and proteins.**

▼ **Question:** Membrane have ____ of proteins, _____ of lipids and _____ of Carbohydrate.

Answer : Membrane have 50% of proteins, 47% of lipids and 3 % of Carbohydrate.

- **The major lipids are phospholipids that are arranged in a bilayer.**
- **The ratio of protein and lipid varies considerably in different cell types.**

- **In human beings, the membrane of the erythrocyte has approximately 52 per cent protein and 40 per cent lipids.**
- The lipid bilayer serves primarily as a structural backbone of the membrane
- **Also, the lipids are arranged within the membrane with the polar head towards the outer sides and the hydrophobic tails towards the inner part.This ensures that the nonpolar tail of saturated hydrocarbons is protected from the aqueous environment.**
- A**mphipathic** ; that is, they contain both hydrophilic and hydrophobic regions.
- It provides the barrier that prevents random movements of materials into and out of the cell.
- **As the polar molecules cannot pass through the nonpolar lipid bilayer, they require a carrier protein of the membrane to facilitate their transport across the membrane.**
- The myelin sheath acts primarily as electrical insulation for the nerve cell it encloses, a function that is best carried out by a thick lipid layer of high electrical resistance with a minimal content of protein.The myelin sheath insulates the nerve cell from the surrounding environment, which increases the velocity at which impulses can travel along the axon.

Fluidity

- Lateral movement of phospholipids.
- Q**uasi-fluid nature of lipid enables lateral movement of proteins within the overall bilayer. This ability to move within the membrane is measured as its fluidity.**
- **The fluid nature of the membrane is also important from the point of view of functions like cell growth, membrane biogenesis, formation of intercellular junctions, secretion, endocytosis, cell division etc.**

Modification of lipids

- If the substitution is a carbohydrate, the molecule is a **glycolipid**.
- If the carbohydrate is a simple sugar, the glycolipid is called a **cerebroside**;

- if it is a small cluster of sugars that includes sialic acid, the glycolipid is called a **ganglioside** .
- If phosphate present with lipid,it is called **phospholipid**.
- If Phospholipid have glycerole backbone,it is **Phosphoglycerides**.
- If lipid+sphingoid base present , it is **sphingolipids**.
- If sphingolipids + residual sugar ,then = **Glycosphingolipids**.
- Alcohol + Phosphate+2 Fatty Acid = Glycerophospholipids .
- Alcohol + Phosphate + 1 Fatty Acid = Sphingomyelin.
- A type of glycolipids called Galactocerebroside , which is formed when a galactose is added to ceramide.

The Nature and Importance of the Phospho-Lipid Bilayer

- Each type of cellular membrane has its own characteristic lipid com-position, differing from one another in the types of lipids, the nature of the head groups, and the particular species of fatty acyl chain(s).
- The lipids of a membrane are more than simple structural elements; they can have important effects on the biological properties of a membrane.
- Lipid composition can determine the physical state of the membrane and influence the activity of particular membrane proteins.
- Membrane lipids also provide the precursors for highly active chemical messengers that regulate cellular function
- The entire lipid bilayer is only about 60 Å (6 nm) thick.
- Amphipathic in nature.
- Because of thermodynamic considerations, the hydrocarbon chains of the lipid bilayer are never exposed to the surrounding aqueous solution. Consequently, membranes are never seen to have a free edge; they are always continuous, unbroken structures. As a result, membranes form extensive inter-connected networks within the cell. Because of the flexibility of the lipid bilayer, membranes are deformable and their overall shape can change, as occurs during locomotion or cell division.

- The lipid bilayer is thought to facilitate the regulated fusion or budding of membranes.
- For example, the events of secretion, in which cytoplasmic vesicles fuse to the plasma membrane , or of fertilization, where two cells fuse to form a single cell, involve processes in which two separate membranes come together to become one continuous sheet .
- The importance of the lipid bilayer in maintaining the proper internal composition of a cell, in separating electric charges across the plasma membrane, and in many other cellular activities
- Another important feature of the lipid bilayer is its ability to self-assemble.

Self-assumble forming Liposome

- Important feature of the lipid bilayer is its ability to self-assemble.
- When a small amount of phosphatidyl choline is dispersed in an aqueous solution, the phospholipid molecules assemble spontaneously to form the walls of fluid-filled spherical vesicles, called liposomes .

The Asymmetry of Membrane Lipids

- The lipid bilayer consists of two distinct leaflets that have a distinctly different lipid composition.
- The different classes of lipids exhibit different properties.
- Carbohydrates present on outer leaflet. All the glycolipids of the plasma membrane are in the outer leaflet where they often serve as receptors for extracellular ligands.

▼ Abundent phospholipid in inner membrane (Inner leaflet)

1. Phosphatidyl ethanolamine
2. Phosphatidyl serine

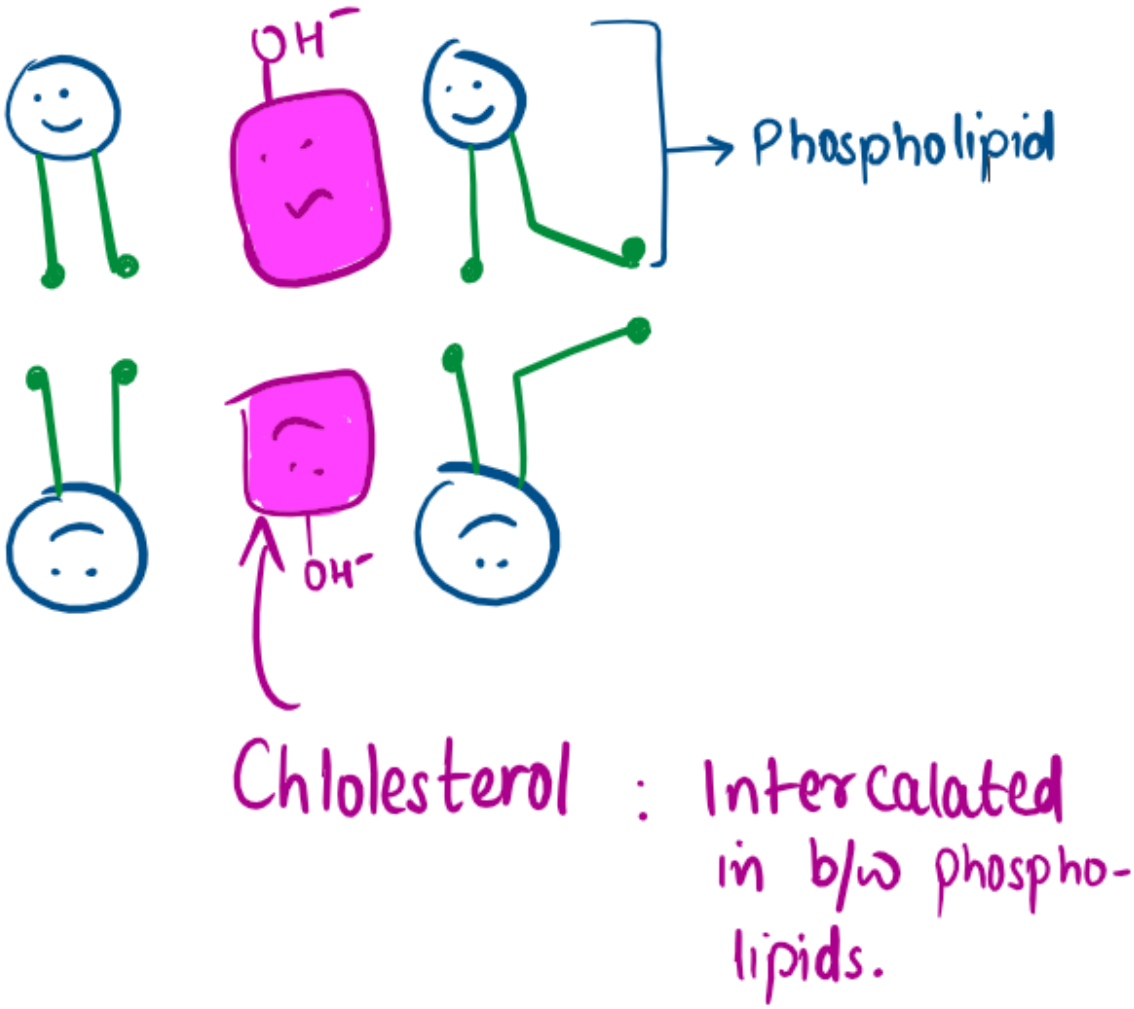
- Phosphatidylethanolamine, which is concentrated in the inner leaflet, tends to promote the curvature of the membrane, which is important in membrane budding and fusion.
- Phosphatidyl serine, which is concentrated in the inner leaflet, has a net negative charge at physiologic pH, which makes it a candidate for binding positively charged lysine and arginine residues, such as those adjacent to the membrane-spanning α helix of glycophorin A.
- Phosphatidylinositol (PI), which is concentrated in the inner leaflet, can be phosphorylated at different sites on the inositol ring, which converts the lipid into a phosphoinositide.phosphoinositides play a key role in the transfer of stimuli from the plasma membrane to the cytoplasm

▼ Abundent phospholipids in outer membrane (outer leaflet)

1. Phosphatidy choline
2. Sphingo-mylin

Cholesterol

- Intercalated in between phospholipids.
- Cholesterol have -OH functional group directed outside each membrane.



Factor affect Fluidity of Membrane

Temperature:

- Increase temperature ; Fluidity increase.

Cholesterol :

- Increase cholesterol ; Fluidity decrease

Unsaturation of fatty acid:

- More unsaturated; Fluidity increase

Types of Membrane lipids

1. Phosphoglycerides
2. Sphingolipids
3. Cholesterole

Phosphoglycerides

Phospholipids vs Phosphoglycerides

- Most membrane lipids contain a phosphate group, which makes them phospholipids .
- Because most membrane phospholipids are built on a glycerol backbone, they are called phosphoglycerides .

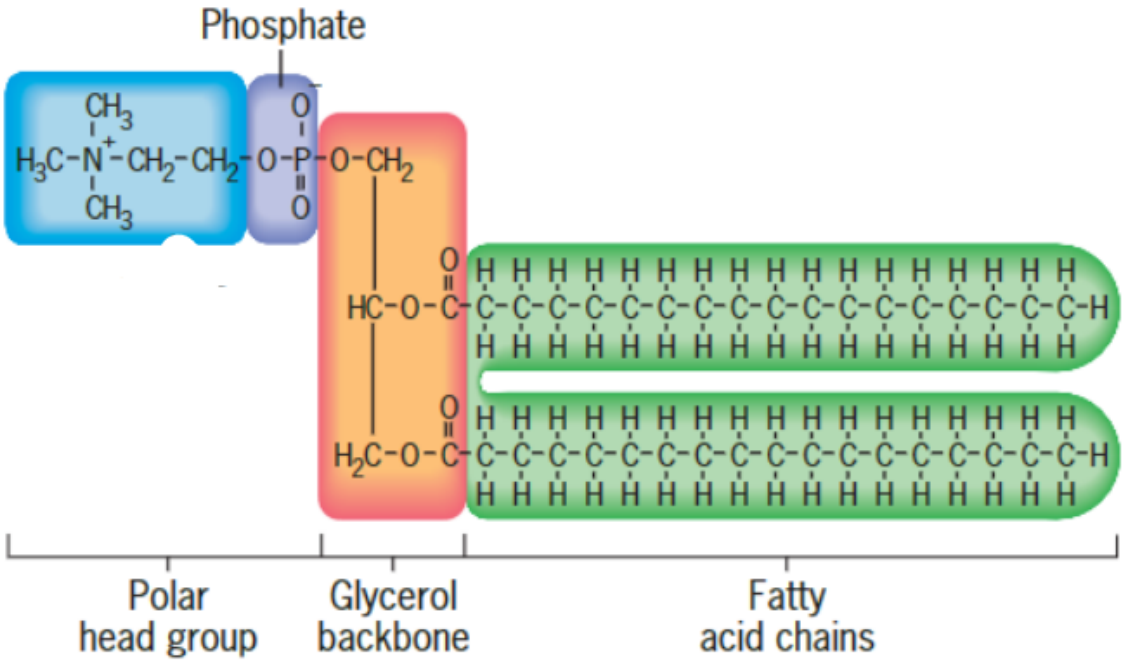


Figure : Phosphoglycerides . The molecule consists of a glycerol backbone whose hydroxyl groups are covalently bonded to two fatty acids and a phosphate group.

- Unlike triglycerides, which have three fatty acids and are not amphipathic, membrane glycerides are diglycerides —only two of the hydroxyl groups of the glycerol are esterified to fatty acids; the third is esteri-fied to a hydrophilic phosphate group.

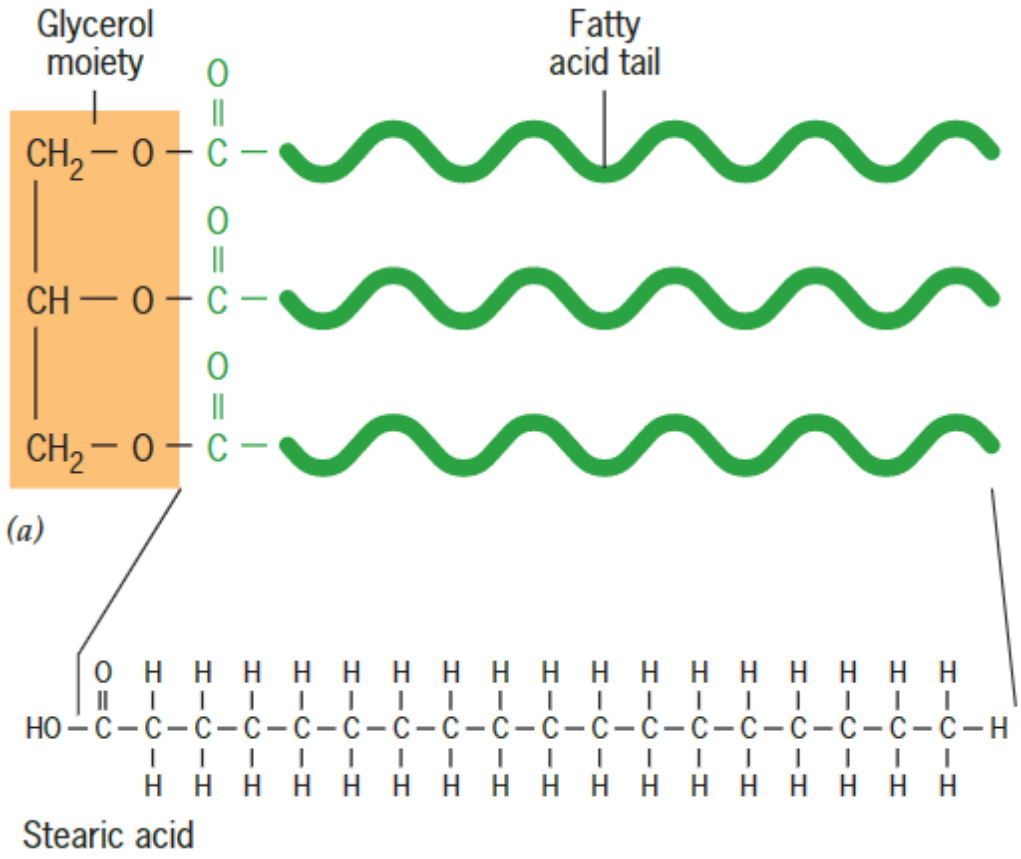
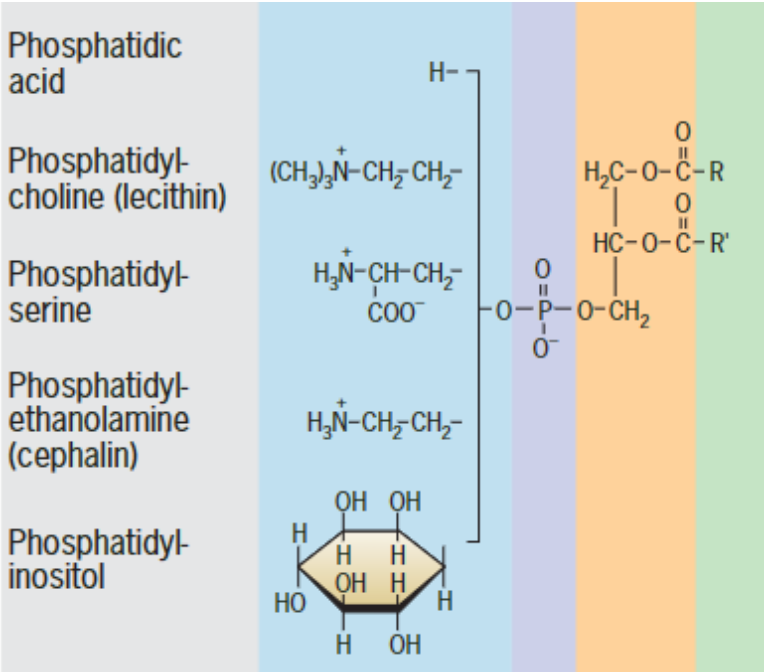


Figure : Fat or Triglyceride or Triacylglycol or Neutral Fat

- Without any additional substitutions beyond the phosphate and the two fatty acyl chains, the molecule is called phosphatidic acid , which is virtually absent in most membranes. Instead, membrane phosphoglycerides have an additional group linked to the phosphate, most commonly either choline (forming phosphatidylcholine , Lecithin , PC), ethanolamine (forming phosphatidylethanolamine , cephalin , PE), serine (forming phosphatidylserine , PS), or inositol (forming phosphatidylinositol , PI).



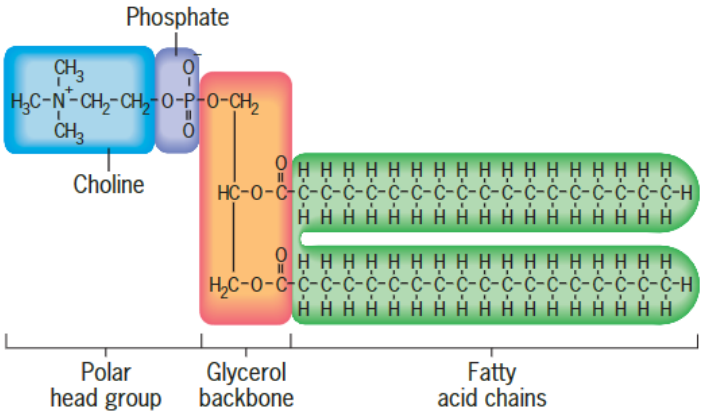


Figure : Phosphatidylcholine. The molecule consists of a glycerol backbone whose hydroxyl groups are covalently bonded to two fatty acids and a phosphate group. The negatively charged phosphate is also bonded to a small, positively charged choline group(phosphorylcholine). The end of the molecule that contains the phosphorylcholine is hydrophilic, whereas the opposite end, consisting of the fatty acid tail, is hydrophobic

- Each of these groups (additional substitutions beyond the phosphate and the two fatty acyl chains) is small and hydrophilic and, together with the negatively charged phosphate to which it is attached, forms a highly water- soluble domain at one end of the molecule, called the head group .
- At physiologic pH, the head groups of PS and PI have an overall negative charge, whereas those of PC and PE are neutral. In contrast, the fatty acyl

chains are hydrophobic, unbranched hydrocarbons approximately 16 to 22 carbons in length.

- A membrane fatty acid may be fully saturated (i.e., lack double bonds), monounsaturated (i.e., possess one double bond), or polyunsaturated (i.e., possess more than one double bond).
- Phosphoglycerides often contain one unsaturated and one saturated fatty acyl chain.
- Recent interest has focused on the apparent health benefits of two highly unsaturated fatty acids (EPA and DHA) found at high concentration in fish oil. EPA and EPA and DHA are described as omega-3 fatty acids because their last double bond is situated three carbons from the omega (CH 3) end of the fatty acyl chain.

Glycolipids

- Glycolipids are interesting membrane components. Relatively little is known about them, yet tantalizing hints have emerged to suggest they play crucial roles in cell function. The nervous system is particularly rich in glycolipids. The myelin sheath pictured in Figure 4.5 contains a high content of a particular glycolipid, called galactocerebroside , which is formed when a galactose is added to ceramide. Mice lacking the enzyme that carries out this reaction exhibit severe muscular tremors and eventual paralysis. Similarly, humans who are unable to synthesize a particular ganglio-side (G M3) suffer from a serious neurological disease characterized by severe seizures and blindness. Glycolipids also play a role in cer-tain infectious diseases; the toxins that cause cholera and botulism both enter their target cell by first binding to cell-surface ganglio-sides, as does the influenza virus.

Sphingolipids

- Sphingolipids consist of sphingosine linked to a fatty acid by its amino group. This molecule is a ceramide. The various sphingosine- based lipids have additional groups esterified to the terminal alcohol of the sphingosine moiety. If the substitution is phosphorylcholine, the molecule is sphingomyelin, which is the only phospholipid of the membrane that is not built with a glycerol backbone. If the substitu-tion is a carbohydrate, the molecule is a glycolipid. If the carbohy-drate is a simple sugar, the glycolipid is called a cerebroside; if it is a small cluster of sugars that includes sialic acid, the glycolipid is called a ganglioside .

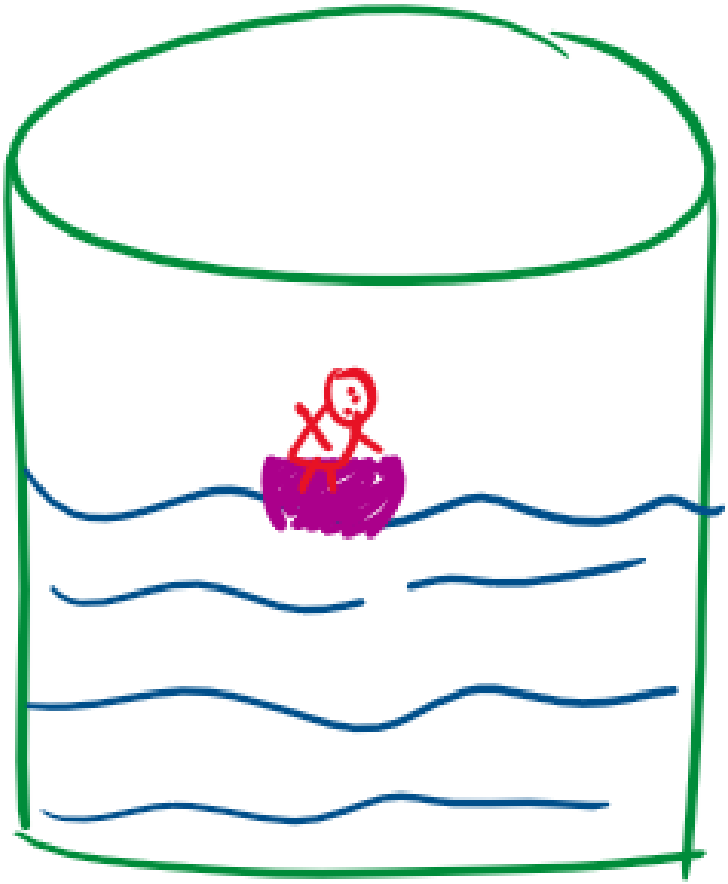
Hundreds of different gangliosides have been identified by differences in their carbohydrate chains. Because all sphingolipids have two long, hydrophobic hydrocarbon chains at one end and a hydrophilic region at the other, they are also amphipathic and

Sphingolipids

- A less abundant class of membrane lipids, called sphingolipids , are derivatives of sphingosine, an amino alcohol that contains a long hydrocarbon chain.
- Glycosphingolipid contain :
    1. Sphingosine backbone :
        a. sphingoid base (e.g. sphingosine and ceramides)
        b. Fatty Acid
    2. Sugar residues
- A sphingolipid is a type of lipid comprised of a sphingoid base (e.g. sphingosine and ceramides) and sugar residue(s).
    - The two are joined together by a glycosidic bond.

Lipid Raft

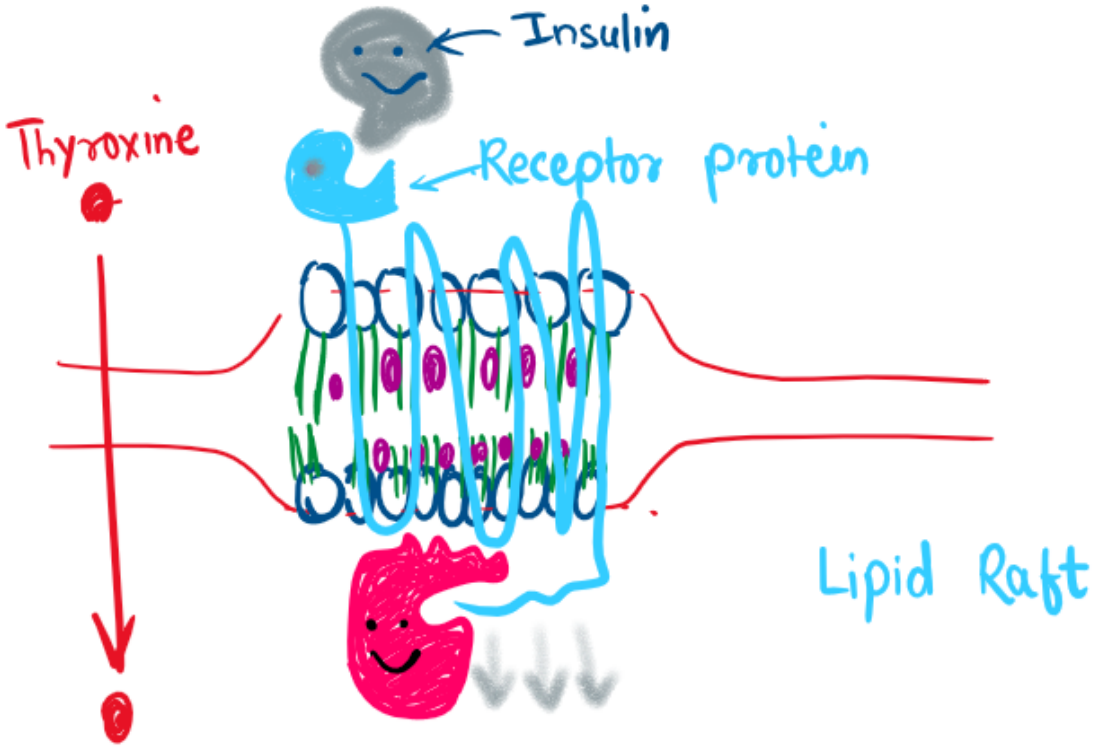
Analogy:



- Lipid rafts can be compared to a frog floating on a raft in a pond. Just as a raft floats on top of the water and provides a stable platform for the frog, a lipid raft is a small, floating platform made up of lipids that provides a stable environment for certain molecules and proteins within the cell membrane.
- Like a frog hopping onto the raft to rest, certain molecules can associate with the lipid raft, which is made up of specific types of lipids that differ from those found in the surrounding membrane. These specific lipids are known to be more ordered and tightly packed, which can create a distinct, stable environment for the molecules and proteins that associate with the raft.
- Similarly, the frog can move around on the raft to reach different parts of the pond, and in the same way, molecules and proteins can move within the lipid raft

to reach different parts of the cell membrane. The raft can also act as a signaling platform, just as the frog can use its croak to signal to other frogs.

- Overall, the lipid raft can be thought of as a floating platform within the cell membrane, providing a stable environment for certain molecules and proteins, and facilitating communication and signaling between cells.



Recepters and their associated proteins are rafting in membrane